Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	)	GN Docket No. 14-177
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	)	IB Docket No. 15-256
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band	)	RM-11664
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	)	WT Docket No. 10-112
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	)	IB Docket No. 97-95

To: The Commission

PETITION FOR RECONSIDERATION

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SUMMARY

The Spectrum Frontiers proceeding is a project to resolve "complex sharing issues" in order to provide the greatest amount of broadband service to all consumers. The Commission recognizes that millimeter wave ("mmW") spectrum provides "inherent opportunities… to facilitate robust shared access."[1]

Boeing has submitted substantial evidence demonstrating that "coexistence is possible" between broadband satellite and terrestrial systems in mmW spectrum without burdening existing or future terrestrial operations in this spectrum.[2] Although the *Order* takes some steps to promote spectrum sharing, its efforts to facilitate this co-existence fall short in several critical respects and create regulatory uncertainty, thus disserving the public interest.

First, the *Order* unreasonably adopts a base station power limit of 75 dBm for the upper microwave flexible use service ("UMFUS"), twenty times greater than the proposed power limit in the Commission's draft rule. The extensive and compelling record shows that (1) a much lower power level is adequate for the robust deployment of UMFUS, and (2) higher power levels the *Order* adopts will substantially impede spectrum sharing with broadband satellite systems.

Second, the *Order* fails to adopt beamforming and power control requirements for UMFUS, creating substantial regulatory uncertainty regarding spectrum sharing. Although these practices are likely to be integral to UMFUS, the *Order* does not provide any regulatory framework for how these measures will be implemented. As a result, satellite service and other UMFUS operators lack the regulatory certainty necessary to effectively engineer their systems.

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[1] Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, GN Docket No. 14-177, *Report and Order and Further Notice of Proposed Rulemaking*, FCC 16-89, ¶ 2 (July 14, 2016).

[2] *Id*, ¶ 498 (explaining that "we recognize that Boeing has submitted a study which shows that coexistence is possible, even at the higher PFD level").

Third, by moving some of the Part 101 technical rules into the new Part 30 UMFUS Rules, the *Order* exacerbates regulatory uncertainty regarding the ability to share spectrum. In particular, the relocation of the Part 101 rules arguably applies those legacy rules to all *future* UMFUS licensees throughout the 27.5-28.35 ("28"), 37.0-38.6 ("37") and the 38.6-40.0 ("39") GHz bands. Further, the rules are no longer clear that the provisions for fixed point-to-point and fixed point-to-multipoint operations apply solely to systems that lack mobile operations.

Fourth, the *Order* arbitrarily disregards the need for and suitability of additional downlink spectrum for the fixed-satellite service ("FSS") in the 42.0-42.5 ("42") GHz band. As the Commission is well aware, broadband services are asymmetric, with consumers demanding far more downlink capacity than uplink capacity. Because Boeing's systems will be able to share the 42 GHz bands with terrestrial UMFUS licensees, no reason exists for the Commission to refrain from providing FSS access to this spectrum.

Fifth, the *Order* arbitrarily limits the siting of protected FSS earth stations in the 28 and 37/39 GHz bands to three facilities per county or partial economic areas ("PEA") and in locations where no more than 0.1 percent of the population (county or PEA) will be in the earth station's exclusion zone. Although the intent of these rules is to encourage satellite licensees to locate protected earth stations in rural areas, the adopted rules have the opposite effect. The Commission should further its original intent by requiring only that earth station exclusions zones in the 28 and 37/39 GHz bands affect no more than 0.1 percent of the U.S. population.

Boeing therefore urges the Commission to reconsider these elements of the *Order* and to adopt the rule changes identified in this petition. By doing so, the Commission will better achieve its objective of promoting highly efficient and beneficial spectrum sharing in mmW spectrum, and thereby maximize the broadband services available to all Americans.

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To: The Commission

PETITION FOR RECONSIDERATION

The Boeing Company ("Boeing"), through its counsel and pursuant to Section 1.429 of the Commission's rules,[3] petitions the Commission to reconsider aspects of its Order ("*Order*") in the above captioned proceeding.[4] The Commission acknowledges that "coexistence is

[3] 47 C.F.R. § 1.429.

[4] Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, *et al.*, GN Docket No. 14-177, *Report and Order and Further Notice of Proposed Rulemaking*, FCC 16-89 (July 14, 2016) ("*Order*" or "*Further Notice*").

possible" between broadband satellite and terrestrial systems in the 37.5-40.0 ("37/39") GHz band.[5] This coexistence can be achieved without burdening existing or future terrestrial licensees in the 37/39 GHz band. Non-burdensome spectrum sharing can also exist between satellite and terrestrial services in other bands, including the 27.5-28.35 ("28") GHz, the 42.0-42.5 ("42") GHz and the 50.4-52.4 ("50") GHz bands.

The *Order* takes steps to promote highly beneficial and efficient spectrum sharing. But the *Order* fails in certain critical respects to fully facilitate this co-existence of services. The Commission should therefore reconsider these issues to provide the regulatory certainty necessary to support private sector investment in global broadband satellite systems, thereby ensuring that millimeter wave ("mmW") spectrum is promptly used nationwide (and worldwide) to provide very high data rate communications services to *all* Americans.

I. THE COMMISSION SHOULD ENCOURAGE PRIVATE SECTOR INVESTMENT IN GLOBAL SATELLITE SYSTEMS TO RESOLVE THE PERSISTENT DIGITAL DIVIDE

Section 706 of the Telecommunications Act of 1996 requires the Commission to take immediate corrective steps if "advanced telecommunications capability" is not "being deployed to all Americans in a reasonable and timely fashion," including "by removing barriers to infrastructure investment and by promoting competition in the telecommunications market."[6] The Commission has repeatedly concluded that advanced telecommunications capability is not

[5] *Further Notice*, ¶ 498 (explaining that "we recognize that Boeing has submitted a study which shows that coexistence is possible, even at the higher PFD level").

[6] 47 U.S.C. § 1302(b). The Communications Act further mandates the Commission to manage spectrum resources "to make available, so far as possible, to all the people of the United States . . . rapid, efficient, Nation-wide, and world-wide" communications services, 47 U.S.C. § 151, and "the equitable distribution of radio service throughout the nation." 47 U.S.C. § 307(b).

being deployed to all Americans in a reasonable and timely fashion.[7] As the Commission documented, there exists "a persistent urban-rural divide in access to broadband services, with Americans in rural areas and on Tribal lands approximately ten times more likely than those Americans in urban areas to lack access" to services able to provide advanced telecommunications capability."[8]

Although the Commission has tried to address the substantial urban-rural divide, the Commission's "policies to encourage and accelerate broadband deployment over the last seven years just haven't worked."[9] In response, the Commission should adopt policies that promote large infrastructure investment by the private sector, including the launch of global satellite systems that can provide very high data rate broadband communications services to all locations in the United States (and the world) on a comprehensive and geographically uninterrupted basis.

The capabilities of broadband satellite systems are advancing rapidly, resolving prior Commission concerns regarding the speed,[10] latency,[11] and capacity of such systems.[12] Boeing, for example, announced the development of a non-geostationary satellite orbit ("NGSO") fixed-satellite service ("FSS") system that can operate in the V-band to provide very high data

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[7] *See* Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, *2016 Broadband Progress Report*, 31 FCC Rcd 699, 701, 750-51, ¶¶ 4 and 120-24 (2016) ("*2016 Broadband Progress Report*").

[8] *Id*., ¶ 121.

[9] *Id.*, Statement of Commissioner Ajit Pai.

[10] *See id.*, ¶¶ 3, 48.

[11] *See id.* at 727, ¶ 67.

[12] *See id.*, ¶ 47 n.162.

rate services to all consumers.[13] Boeing's NGSO FSS system provides a dramatic opportunity to bridge the digital divide without protracted build out delays.

Boeing has shown that the Commission can enable the significant opportunity offered by NGSO FSS systems without having to choose between satellite and terrestrial 5G services in the V-band. The same technological developments that have opened mmW spectrum for broadband deployment also enable sharing between 5G and broadband satellite systems. As the Commission has acknowledged, Boeing has provided technical studies showing that spectrum sharing between satellite terminal receivers and UMFUS systems is feasible in the 37/39 GHz band.[14] Boeing has also demonstrated in the context of the *Further Notice* that non-intrusive spectrum sharing is possible in other significant portions of the V-band.[15]

Facilitating spectrum sharing in mmW bands is critical. Boeing's NGSO FSS system would provide much needed assurance that mmW spectrum will be used expeditiously to serve all Americans, as Congress directed, and not just those "in densely populated areas."[16] Further, spectrum sharing in the V-band will ensure that the spectrum is used intensively, thus adhering to the Act's mandate that spectrum be used equitably and efficiently.[17]

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[13] *See* The Boeing Company Application for Authority to Launch and Operate a Non-Geostationary Low Earth Orbit Satellite System in the Fixed-Satellite Service (S2966), SAT-LOA-20160622-00058 (filed June 22, 2016).

[14] *Further Notice*, ¶ 498.

[15] *See* Comments of The Boeing Company, GN Docket No. 14-177 (Sept. 30, 2016).

[16] Letter from Brian M. Josef, Assistant Vice President, Regulatory Affairs, CTIA, GN Docket No. 14-177, at 2 (May 24, 2016).

[17] Spectrum sharing is an "essential element" of the Federal spectrum architecture and "[t]echnology innovations of recent years make this transformation eminently achievable." President's Council of Advisors on Science and Technology, Report to the President, "*Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*" (July 2012).

II. THE ORDER FAILS TO CREATE THE REGULATORY CERTAINTY REGARDING SPECTRUM SHARING IN THE 37/39 GHZ BAND NEEDED TO ENCOURAGE BROADBAND INVESTMENT

Section 706 of the Telecommunications Act of 1996 requires that the Commission *remove* barriers to infrastructure investment and *promote* competition to provide all Americans with access to "advanced telecommunications capability," and regulatory uncertainty itself is a barrier to such infrastructure investment and inhibits competition. Providing regulatory certainty is therefore one essential step the Commission must take to promote private sector infrastructure investment and new competition in the broadband telecommunications market. The importance of regulatory certainty is based on decades of Commission experience that such certainty is necessary to support the massive investments in communications infrastructure needed to introduce new broadband services to consumers in all areas of the country consistent with Congressional mandates.[18] As Commissioner Pai explained to Congress, it is a Commission priority "[t]o give entrepreneurs, investors, and innovators the *regulatory certainty* they need to invest in next-generation infrastructure."[19]

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[18] *See, e.g.*, Roaming Obligations of Commercial Mobile Radio Service Providers and Other Providers of Mobile Data Services, *Order on Reconsideration and Second Further Notice of Proposed Rulemaking*, 25 FCC Rcd 4181, ¶ 52 (2010) (explaining regulatory certainty will "help to establish an environment conducive to network deployment and investment"); Petition of Core Communications, Inc. for Forbearance, *Memorandum Opinion and Order*, 22 FCC Rcd 14118, ¶ 16 (2007) (explaining that a regulatory void and uncertainty may harm network investment); "*Connected & On the Go Broadband Goes Wireless*," Report by the FCC Wireless Broadband Access Task Force, 2005 FCC LEXIS 1488, (Feb. 2005) (concluding regulatory uncertainty will adversely affect investment in and deployment of services critical to this country's broadband future); Space Station Licensing Rules and Policies, 18 FCC Rcd 10,760, 10,781, ¶ 45 n.115 (2003) (observing "[t]he Commission has noted on several occasions that regulatory uncertainty can discourage investment, and so unnecessary regulatory uncertainty should be avoided").

[19] Statement of Commissioner Ajit Pai, Federal Communications Commission, Hearing on the FCC's Fiscal 2015 Budget Request, before the Subcommittee on Financial Services and General Government Committee on Appropriations, U.S. Senate (March 27, 2014) (*emphasis added*).

As an immediate example, Boeing's proposed NGSO FSS system could bring vital new broadband services to consumers, increasing competitive options for all Americans and worldwide. Deploying this system, however, requires a vast commitment of resources. To launch its global constellation, Boeing requires regulatory certainty regarding its access to sufficient V-band spectrum to satisfy consumer demand for very high data rate broadband. In critical respects detailed below, the Commission's *Order* fails to establish this regulatory certainty and even injects uncertainty regarding potential future actions. The Commission should therefore further examine some of the critical spectrum sharing opportunities made available by advanced mmW technologies and revise its rules to further promote efficient spectrum use and the regulatory certainty needed to enable a new infrastructure investment.

A. The *Order* Inappropriately Fails to Adopt, or Address, Non-Burdensome Technical Measures that Would Create Regulatory Certainty and Promote Spectrum Sharing in the 37/39 GHz Band

Boeing has repeatedly explained in its filings in this proceeding that robust spectrum sharing between satellite and UMFUS systems is achievable in the 37/39 GHz band if the Commission adopts a few reasonable and non-burdensome measures.[20] Specifically, Boeing explained that sharing would be possible if the Commission were to:

1. Adopt a 5G base station power limit of 62 dBm EIRP,
2. Require 5G systems to use beamforming and power control,
3. Require the confidential disclosure of 5G base station locations,
4. Lift the prohibition on satellite end user receivers in the 37/39 GHz band, and
5. Permit satellites to transmit in the 37/39 GHz band at the ITU power levels.

[20] Boeing made these arguments in written *ex parte* letters filed on May 27, June 17, and July 7, and in detailed oral *ex parte* presentations, the notices for which were filed on May 9 (FCC staff), May 13 (OET staff), May 20 (Chairman and Commissioners' staff), May 25 (Pai's staff), June 6 (FCC staff), June 6 (Commissioners Pai and O'Rielly), June 7 (OET staff), June 16 (Chairman's staff), and June 29 (Commissioner Rosenworcel).

The Commission appropriately agreed to consider the final three of Boeing's proposals in its *Further Notice*. The *Order*, however, declined to adopt Boeing's first proposal, a decision that will unreasonably prevent robust spectrum sharing in the 37/39 GHz band. The Order also fails to acknowledge, much less address, Boeing's second proposal, even though it is essential for providing the certainty needed to enable spectrum sharing between satellite and UMFUS systems in the V-band spectrum. The Commission's refusal to adopt its originally proposed 62 dBm power limit for UMFUS base stations and its oversight regarding Boeing's beamforming and power control arguments represent critical gaps in the reasoning of the *Order* and must be addressed by the Commission on reconsideration.

1. The *Order* Disregards Compelling Evidence that a Power Limit of 62 dBm is Necessary and Appropriate to Facilitate Spectrum Sharing in the 37/39 GHz Band

Based on years of study and after concluding a Notice of Inquiry on the likely operational characteristics of UMFUS systems,[21] the Commission proposed in its *NPRM* to adopt a 62 dBm power limit for UMFUS base stations.[22] The Commission acknowledged that ample support exists to conclude that UMFUS systems could reliably operate within a 62 dBm power limit.[23]

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[21] Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, WT Docket No. 14-177, *Notice of Inquiry*, 29 FCC Rcd 13020 (2014).

[22] *Order*, ¶ 270.

[23] *See* Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, GN Docket No. 14-177, *Notice of Proposed Rulemaking*, FCC 15-138, ¶¶ 273-274 (Oct. 23, 2015) ("*NPRM*"). The Commission observed that "Intel states that "58 dBm (631 watts) EIRP for base station transmitters … could achieve the performance and range for the applications targeted for these bands." Samsung states that, in its field trials, "Based on a 58 dBm EIRP limit, satisfactory communications links were attained even in non-line-of-sight scenarios more than 200 meters away." Straight Path states that "the FCC [should] adopt an EIRP limit of 65 dBm (3160 watts) for base stations operating in the 39 GHz and LMDS bands. This is consistent with the maximum power limit for other spectrum in which mobile services operate, *e.g.*, Cellular, Broadband PCS, WCS, AWS, and 700 MHz bands." *Id.*

Despite the Commission's proposal and the extensive record supporting a base station power limit of 62 dBm, several parties at the last minute sought a 13 dB increase to the Commission's proposed limit. Instead of offering a real technical or policy foundation, they asserted, for example, that "[h]igher power allows adequate headroom to improve and innovate with state-of-the-art technology."[24] The Telecommunications Industry Association in this contention was stating a truism rather than offering a workable principle: *Any* level above what its members actually need – which, on this record is, at most, around 62 or 65 dBm – could be defended as allowing "headroom." But that excuse fails to provide a reasonable basis for selecting any particular level, and such vast "flexibility" for some -- an increase of 13 dBm, from 62 to 75, representing a twenty times increase in power – creates arbitrary uncertainty for others, which fails to serve the public interest.

It remains the case that (1) the vast majority of 5G proponents have described plans for 5G systems that would employ *much* lower power levels to facilitate intra-system sharing between large numbers of UMFUS users in very dense and populous locations; that (2) Boeing correspondingly has shown that broadband satellite systems can operate on an opportunistic basis with such systems in the 37/39 GHz band; and (3) that Boeing has provided detailed documentation (in its filings in advance of the *Order*) explaining the harm of the higher power limit on the capabilities for spectrum sharing.[25] For example, Boeing's technical analysis shows that allowing UMFUS base stations to increase their power by 13 dB to 75 dBm/100 MHz would, if they operate continuously in that mode, reduce the throughput capacity of Boeing's NGSO

[24] *See* Letter from Dileep Srihari, Director, Legislative and Government Affairs, Telecommunications Industry Association, to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177, at 3-4 (June 17, 2016).

[25] *See, e.g.,* Boeing *ex parte* letters dated June 7, 2016, June 16, 2016 and July 5, 2016.

FSS system by more than a factor of two and greatly hinder the ability for opportunistic spectrum sharing in the 37/39 GHz band.[26]

The Commission claims that it need not consider the potential impact on satellite end user terminals in the 37/39 GHz band because the existing rules "prohibit the ubiquitous deployment of satellite earth stations designed to serve individual consumers."[27] Yet the Commission simultaneously and appropriately agreed in its *Further Notice* to consider eliminating this outdated prohibition, which pre-dates modern mmW beamforming technologies. The *Further Notice* rightly acknowledges that spectrum sharing with satellite end user terminals may now be possible, because they "would not cause interference to terrestrial operations."[28] Yet the *Order* makes no attempt to explain the sense in simultaneously *relying on* and *calling into question* this outdated prohibition on sharing.

In reconsidering its adoption of an excessively high power limit for UMFUS base stations, the Commission should also address the ambiguity in the *Order* regarding the maximum permissible directional radiated EIRP level of a single UMFUS emission as compared to the total radiated power ("TRP") of an UMFUS device. Section 30.202 uses a directional maximum EIRP density limit, *i.e.*, 75 dBm/100 MHz, for UMFUS base stations. This rule correctly and effectively limits the maximum directional power density of an UMFUS base station emission, but does not define the base station TRP in all directions. In contrast, the out-of-band emissions rules in Section 30.203 do include a TRP requirement that measures the spherical TRP of the UMFUS device and uses the TRP density to determine the out-of-band emissions.

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[26] *See Ex Parte* Letter of The Boeing Company, GN Docket No. 14-177 (July 5, 2016).

[27] *Order*, ¶ 278 (*citing* 47 C.F.R. § 25.202(a)(1)).

[28] *Further Notice*, ¶ 502.

To provide much needed regulatory certainty, the Commission should restore its proposed UMFUS base station power limit of 62 dBm and adopt TRP density specifications that are applicable to all UMFUS in-band emissions.[29]

2. The *Order* and UMFUS Proponents Acknowledge the Importance of Beamforming and Power Control to Facilitate UMFUS Systems and Spectrum Sharing

Throughout the *Order*, the Commission acknowledges in other contexts the importance of both beamforming and power control to communications services in mmW spectrum.

Beamforming. The *Order* confirms that UMFUS licensees will likely need to employ beamforming to overcome the significant propagation losses that are inherent in the 37/39 GHz band. As the *Order* explains, "the extremely short wavelengths of mmW signals make it feasible for very small antennas to concentrate signals into highly focused beams with enough gain to overcome propagation losses."[30] These highly focused beams will be "as narrow as 1.0 degree" and will be able to direct transmissions at desired receivers, thereby avoiding harmful interference to nearby receivers, be they UMFUS or satellite earth stations.[31]

The *Order* observes that UMFUS licensees "have every incentive to design networks that direct the signals they are transmitting to the locations of the receivers... especially given the propagation characteristics of these frequencies."[32] The *Order* also quotes Intel in noting that

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[29] The TRP density specification should be based on the expected antenna gain to be applied by the UMFUS device and be specified over a coverage volume. For example, an UMFUS base station should limit its emissions to a maximum TRP density of 34 to 42 dBm/100 MHz integrated over a large sector (such as 120 degrees). End-user UMFUS handsets and transportable CPEs should observe TRP densities of 30 dBm/100 MHz and 34 dBm/100 MHz respectively, both over a 4π steradian spherical volume.

[30] *Order*, ¶ 6.

[31] *Id.*, ¶ 65 (citing various technical studies).

[32] *Id.*, ¶ 67.

"[b]eamforming will be an integral part of 5G systems"[33] and "choosing not to use dynamic beamforming technology would reduce throughput at cell edges by about 70 percent."[34] Other UMFUS proponents expressed the same position.[35]

UMFUS proponents also acknowledge that the use of beamforming will enable spectrum sharing. As Ericsson explains, "[b]eamforming is an essential aspect of the UMFUS system, and phased arrays serve to improve the link gain towards the desired receiver, while simultaneously having the benefit of lowering the interference level towards other victims in the environment."[36] Qualcomm also explains that "highly directional 5G antenna systems on base stations/small cells mitigate interference to potential victim receivers because their narrow fixed beams continually move from device to device so any on-axis interference a victim experiences is a limited statistical event."[37] The 5G "Joint Filers" further explain that beamforming could significantly reduce the interfering impact of UMFUS systems operating at higher power levels

[33] Letter from Peter Pitsch, Intel Corporation, GN Docket No. 14-177 (May 24, 2016), Attach. at 4 ("*Intel May 24 Ex Parte Letter*").

[34] *See Order*, ¶ 65 (*citing Intel May 24 Ex Parte Letter*, Attach. at 2).

[35] For example, CTIA states that "[t]o take full advantage of the millimeter wave bands, antenna arrays and beamforming will be required." Comments of CTIA, GN Docket No. 14-177, at 28 (Jan. 28, 2016). Samsung explains that "[h]ybrid beamforming is a key technology" for operation at mmW frequencies. Letter from Robert Kubik, Director, Public Policy, Engineering and Technology, Samsung Electronics, GN Docket No. 14-177, Attach. at 8 (March 11, 2016). Qualcomm explains that "[m]illimeter-wave devices are being designed with an array of multiple antennas employing dynamic beamforming." Reply Comments of Qualcomm Inc., GN Docket No. 14-177, at 9 (Feb. 26, 2016). AT&T explains that "[l]everaging the spectrum bands above 24 GHz for mobile uses will require advanced technologies, including new beamforming techniques." Reply Comments of AT&T, GN Docket No. 14-177, at 7 (Feb. 26, 2016).

[36] Letter from Mark Racek, Sr. Director, Spectrum Policy, Ericsson, GN Docket No. 14-177, at 3 (June 15, 2016) ("*Ericsson June 15 Ex Parte Letter*").

[37] Letter from John W. Kuzin, Vice President & Regulatory Counsel, Qualcomm Corp., GN Docket No. 14-177, at 1 (May 9, 2016).

because the off-axis gain "of the larger array used to deliver the higher EIRP level will be lower than that of the smaller array, thus in-part compensating for the increased EIRP level."[38]

Power Control. The *Order* also acknowledges the importance of power control to facilitate UMFUS systems and mmW spectrum sharing. The *Order* concludes that UMFUS base stations and end user transceivers are likely to employ power control, explaining that technologies such as "adaptive power control will occur naturally because they are inherent characteristics of anticipated 5G technologies."[39] The *Order* explains that power control will be needed "both to avoid draining batteries and to limit intersystem interference."[40]

UMFUS proponents are in accord. As Ericsson explains, 5G systems are engineered "so that a large number of served users are within the power control range, and the maximum EIRP is employed only when the angular spread of the channel to the base station is very low."[41] Intel also explains that in 5G systems, as with cellular networks, "base stations do not transmit all the time and seldom transmit at maximum power, and user devices are power-controlled."[42]

3. The Record in the Spectrum Frontiers Proceeding, as well as Commission Precedent, Supports the Adoption of Specific Beamforming and Power Control Requirements

Boeing's proposal for the Commission to adopt beamforming and power control requirements for UMFUS is clearly supported by Commission precedent and the record in this proceeding, particularly with respect to the technical submissions of the 5G community.

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[38] Letter from Stacey Black, Assistant Vice President - Federal Regulatory, AT&T Services Inc., GN Docket No. 14-177, at 7-8 (June 1, 2016) (*ex parte* letter of AT&T Services Inc., Ericsson, Nokia, Samsung Electronics America, T-Mobile USA, Inc., and Verizon) ("*Joint Filers Letter*").

[39] *Order*, ¶ 294; *see also id.*, ¶ 65.

[40] *See id.* (*citing Intel May 24 Ex Parte Letter*, Attach. at 2-3).

[41] *Ericsson June 15 Ex Parte Letter* at 3.

[42] *Intel May 24 Ex Parte Letter*, Attach. at 3.

Beamforming. The Commission's Part 30 rules already include beamforming requirements for some fixed operations. Section 30.406(b) imports from Part 101 the following limits (*see* Figure 1) on the off-axis transmissions of fixed point-to-point transmitters (which are analogous to the beamforming capabilities of 5G services). The adopted limits are appropriate for UMFUS links using higher gain and EIRP (such as back-haul and point-to-point links) and have been appropriately applied by the Commission to all fixed devices operating above 75 dBm.

Frequency (MHz)	Category	Maximum beamwidth to 3 dB points (included angle in degrees)	Minimum antenna gain (dbi)	Minimum radiation suppression to angle in degrees from centerline of main beam in decibels						
				5° to 10°	10° to 15°	15° to 20°	20° to 30°	30° to 100°	100° to 140°	140° to 180°
38,600 to 40,000[14]	A	n/a	38	25	29	33	36	42	55	55
	B	n/a	38	20	24	28	32	35	36	36

Figure 1 – Excerpt From Section 30.406(b) – Directional Antenna Requirements

For newly authorized UMFUS services, the large majority of 5G proponents have proposed to use phased array antennas for all types of UMFUS devices, including both fixed and mobile terminals and base stations. In characterizing such devices, 5G proponents participated in such industry bodies as 3GPP to develop 5G channel models,[43] which were referenced in their technical filings in this proceeding.[44] The *Order* relied heavily on these technical files to support its conclusions that UMFUS systems will be able to share spectrum effectively with FSS systems, terrestrial FS systems, and with other UMFUS licensees. The Commission should also use these 3GPP models to adopt the following off-axis beamforming requirements (*see* Figure 2).

[43] *See* Study on Channel Model for Frequency Spectrum Above 6 GHz, 3GPP TR38.900 v14.1.0.

[44] *See, e.g.*, AT&T Services, Inc. *Ex Parte*, GN Docket No 14-177, Attach. at 1 (July 7, 2016); Straight Path *Ex Parte*, GN Docket No. 14-177, at 2 n.8 (June 14, 2016); *Joint Filers Letter* at 8.

For an array with half-power beamwidth θ_{HP} at broadside, at an angle if incidence θ, given an array steering angle θ_0 both measured from array broadside, define: $u = \sin(\theta)$ and $u_0 = \sin(\theta_0)$ $u_{HP} = \sin(\theta_{HP})$ $\Delta u = (u - u_0)$

$$\gamma = \left|\left(\frac{\Delta u}{u_{HP}}\right)\right| \quad and \ \gamma_{limit} = \left(\frac{1}{u_{HP}}\right) \qquad with \quad G_E(\theta) = -12(\theta/\theta_E)^2 \quad and \ \theta_E = 90°$$

$$for\ \gamma_{min}(k) < \gamma \le \gamma_{max}(k) \ \ and \ \gamma, \gamma_{max}(k) < \gamma_{limit}$$

$$G_{max}(\gamma) = G_E(\theta) + SLL_{dBr}(k) - \delta * (\gamma - \gamma_{min}(k))$$

Normalized γ_{min}	Normalized γ_{max}	Sidelobe level SLL_{dBr}	Slope δ
1.00	1.675	-11.5	0
1.675	3.375	-11.5	2.65
3.375	5.625	-16.0	2.00
5.625	10	-20.5	1.257
10	19	-26.0	0.667
19	37	-32.0	0.111
37	Inf	-34.0	0

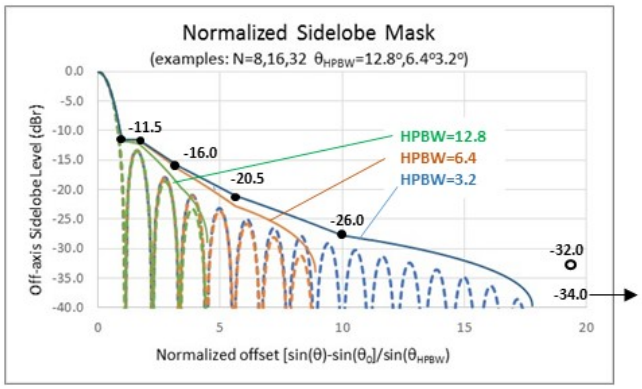

Figure 2 – Proposed Beamforming (Off-axis) Requirements for UMFUS Transmitters

The identified levels and the resulting 'mask' shown above are far less stringent than the fixed sidelobe masks that are often adopted for fixed or physically steered antennas, and include allowances for electronic beam steering and errors in excess of the ideal predicted pattern. Compliance with such off-axis regulations could be easily achieved using low-cost planar array antennas or other technologies and could be easily verified concurrent with the verification of the EIRP density compliance of the device.[45] Therefore, the proposed beamforming requirements that result from the 3GPP channel models would impose no burden on UMFUS equipment beyond what has already been contemplated by 5G equipment manufacturers and relied upon by the Commission in justifying the *Order*'*s* conclusions.

Power Control. The existing record in the *Spectrum Frontiers* proceeding also provides sufficient support for the Commission to adopt power control requirements for UMFUS systems. In fact, Section 30.405 of the newly adopted rules already instructs some UMFUS licensees that "the average power delivered to an antenna in this service must be the minimum

[45] *See Order*, ¶¶ 291-293. The Commission relied upon analyses by the Joint Filers that used planar array patterns with much lower sidelobes (e.g., 30 dB sidelobes from Chebyshev tapered patterns) to assess the aggregate interference impact from UMFUS base stations.

amount of power necessary to carry out the communications desired."[46] Such a requirement is effectively consistent with a general obligation to employ power control.[47]

Significant Commission precedent exists for mandating power control in wireless services such as UMFUS.[48] In adopting power control requirements for other wireless services, the Commission has explained that "in cellular systems, mobile device transmit (*i.e.*, uplink) power control is a key radio resource management function for improving system capacity, coverage, and user quality (data rate or voice quality), lowering battery consumption, and controlling interference to adjacent cells of the same system."[49]

The *Order* therefore should have addressed (and accepted) Boeing's argument that adopting power control requirements for UMFUS would enable spectrum sharing in the 37/39 GHz band without burdening existing or future terrestrial licensees. Specifically, the Commission should extend the Section 30.405 power control rules to all UMFUS transmitters. The Commission should also adopt language similar to its existing power control rules found in Section 25.204(e)(3) to limit the amount of error allowed in the power control system.[50] A power control accuracy rule limiting the power control error to within 3 dB of the average fading condition would be appropriate, with exceptions allowed for fast-fading transient conditions.

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[46] 47 C.F.R. § 30.405.

[47] This power minimization requirement, however, appears to apply only to fixed point-to-point and fixed point-to-multipoint operations in the 37/39 GHz band. *See* Part 30, Subpart E.

[48] The Commission adopted power control rules for the Citizens Broadband Radio Service, *see* 47 C.F.R. § 96.41(c), for white space devices in television broadcast spectrum, *see* 47 C.F.R. § 15.709(a)(4), for Unlicensed National Information Infrastructure (U-NII) devices, *see* 47 C.F.R. § 15.407(h), and for Wireless Communications Service devices. *See* 47 C.F.R. § 27.50(a).

[49] Rules for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, FCC 12-130, *Order on Reconsideration*, 27 FCC Rcd 13651, ¶ 77 (Oct. 17, 2012).

[50] *See, e.g.*, 47 C.F.R. § 25.204(e)(3).

Requiring power control clearly promotes spectrum sharing and lessens the impact to other UMFUS, FS and FSS systems sharing the spectrum. Boeing estimates that, if UMFUS base stations employ power control, the average EIRP used within each UMFUS cell may be reduced below the 75 dBm level by anywhere from 3 to 15 dB. Such results are fully consistent with those submitted into the record by the wireless community, in particular by the Joint Filers based on real-world measurement data from AT&T's existing cell site operations.[51]

4. Given the Importance of Beamforming and Power Control, it was Necessary to Consider Boeing's Proposal that These Measures be Included in the UMFUS Rules

Given the substantial evidence of the importance of beamforming and power control, it was necessary for the *Order* to address Boeing's proposal that such practices be formalized to facilitate spectrum sharing with earth station receivers in the 37/39 GHz band.[52] The Commission must demonstrate a "rational connection between the facts found and the choice made."[53] In the *Order*, however, the Commission, even while detailing the importance of beamforming and power control to enable spectrum sharing by UMFUS systems, failed to consider the adoption of beamforming or power control rules to enable spectrum sharing in the

[51] *Joint Filers Letter*, Exhibit C.

[52] The *Order* considers an unrelated satellite industry request to adopt rules to prevent excessive emissions into satellite receivers in space. The *Order* declines to adopt such measures "in the absence of more credible support for the proposition that satellite systems will receive harmful interference from mmW mobile systems." *Order*, ¶ 67. Regardless of whether the record justified adopting such measures in the 28 GHz band, the record clearly documents the significant need for (and potential public interest benefits of) employing these technologies to ensure robust spectrum sharing in the 37/39 GHz band.

[53] Motor Vehicle Mfr. Ass'n v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43 (1983).

37/39 GHz band. When an agency thus has not provided "a reasoned explanation or where the record belies the agency's conclusion," it has failed to follow proper administrative procedure.[54]

As the Commission acknowledges in its *Further Notice*, "Boeing has submitted a study which shows that coexistence is possible" between satellite earth station receivers and UMFUS systems in the 37/39 GHz band.[55] The *Further Notice* seeks comment on specific rule changes that would help make such highly efficient spectrum sharing possible.[56] Given the public interest importance of facilitating spectrum sharing, and the Commission's acknowledgement that spectrum sharing is feasible in the 37/39 GHz band, it would be arbitrary and unreasonable for the Commission to conclude that it need not consider Boeing's proposal to codify beamforming and power control requirements for the 37/39 GHz band.

It would also be insufficient for the Commission to conclude (were it to have considered the question) that the benefits of beamforming and power control are likely to occur in the 37/39 GHz band absent regulation. UMFUS proponents have asserted that UMFUS systems are likely to rely on beamforming and power control to operate successfully and the use of such techniques will not burden UMFUS licensees. Perhaps so. The Commission's longstanding policy of creating regulatory certainty, however, dictates the consideration of modest regulatory measures requiring the use of beamforming and power control to facilitate robust spectrum sharing in the 37/39 GHz band and to encourage investment in new infrastructure and services. The Commission's statutory obligation to manage spectrum resources to serve the public interest, together with the basic requirements of administrative procedure, necessitate no less.

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[54] Petroleum Communications, Inc. v. FCC, 22 F.3d 1164, 1172 (DC Cir. 1994).

[55] *Further Notice*, ¶ 498.

[56] For example, the *Further Notice* seeks comment on eliminating the outdated prohibition on satellite earth station receivers in the 37/39 GHz band. *See id.*, ¶¶ 500-502.

B. The *Order* Exacerbates Regulatory Uncertainty Regarding Sharing in the 28 and 37/39 GHz Bands By Unreasonably Moving Some Part 101 Rules Into Part 30

The Commission's *Order* creates a new rule part, Part 30, for UMFUS licensees[57] and permits Local Multipoint Distribution Service ("LMDS") and 39 GHz licensees to provide UMFUS mobile services in their licensed territories. Both of these measures were contemplated by the *NPRM*.[58] The *Order*, however, goes significantly further, by moving the existing Part 101 technical rules for point-to-point and point-to-multipoint operations into Part 30.[59] This action, which was not anticipated in the *NPRM*,[60] could have significant unintended consequences and cause tremendous regulatory uncertainty by adopting potentially inconsistent and conflicting rules for terrestrial operations. The Commission should reconsider this portion of the *Order* by correcting these problems in two simple, non-burdensome ways explained below.

1. The Commission Should Address the Ambiguity and Unworkable Uncertainty the *Order* Creates Regarding the Rules for Fixed Versus Mobile UMFUS Operations

Prior to the *Order*, the Part 101 technical rules for the LMDS and 39 GHz services applied only to the relatively small number of remaining licensees in their licensed portions of the 28 and 39 GHz bands. The rules applied solely to traditional fixed (*i.e.*, no mobile) point-to-point and fixed point-to-multipoint systems, as evidenced by their codification in Part 101, "which governs fixed microwave services."[61]

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[57] *Order*, ¶ 161; *see also NPRM*, ¶ 177.

[58] *See NPRM*, ¶¶ 177-178.

[59] *See Order*, ¶ 243.

[60] The *NPRM* only contemplated allowing the existing rules to be used by "current or future fixed point-to-point or point-to-multipoint systems that are operating consistent with the current Part 101 rules," which are applicable solely to the LMDS and 39 GHz services. *NPRM*, ¶ 271.

[61] *Order*, ¶ 159.

As a result of the relocation of the Part 101 rules into the new Part 30, however, the legacy rules might arguably apply to *all* future UMFUS licensees, across the entire 28, 37 and 39 GHz bands. Further, the rules are no longer clear that the provisions for fixed point-to-point and fixed point-to-multipoint operations apply solely to systems that completely lack mobile operations. Some parties may argue that the rules create three different operating modes for UMFUS systems – mobile, point-to-point, and point-to-multipoint – each with its own power limits and antenna requirements. Specifically, the UMFUS rules could be construed to permit:

- UMFUS *base* stations providing *mobile* services to transmit at a maximum EIRP density of 75 dBm/100 MHz with directional antennas, but with *no restrictions* on antenna performance,[62] or
- UMFUS *hub* stations providing *fixed point-to-point* services to transmit at a maximum ERP of 55 dBW (85 dBm) with directional antennas and with appropriate restrictions on EIRP density and off-axis antenna performance,[63] or
- UMFUS *hub* stations providing *fixed point-to-multipoint* services to transmit at an EIRP of 55 dBW (85 dBm) with *no restrictions* on EIRP density, or omni- or multi-directional antenna performance.[64]

Presumably, the Commission intended to make its legacy rules for fixed point-to-point and fixed point-to-multipoint systems available solely to licensees that provide *exclusively* fixed services (*i.e.*, no mobile operations), and to apply its new rules to UMFUS systems that include mobile users. Neither the *Order* nor the rules, however, make this distinction sufficiently clear.

As a result, the *Order* could be misconstrued to provide UMFUS licensees with a choice regarding the requirements applicable to their systems. Licensees might argue that some UMFUS facilities qualify as both "base stations" and "hub stations" (the rules fail to distinguish

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[62] *See* 47 C.F.R. § 30.202(a)

[63] *See* 47 C.F.R. § 30.406(b).

[64] *See* 47 C.F.R. § 30.405 and 47 C.F.R. § 30.406(a)

adequately between the two), potentially enabling interchangeable operations between different modes. This would create tremendous uncertainty for all potential users of the 28 and 37/39 GHz bands, be they other UMFUS licensees, FS operators, or operators of FSS earth stations.

The Commission should resolve this regulatory uncertainty by making a clear distinction between the rules for fixed and mobile UMFUS operations. This can best be achieved by moving the legacy rules for fixed operations in the 28 and 37/39 GHz bands back into Part 101 and limit their application in the 39 GHz band to fixed point-to-point links that were previously constructed and are currently operating. Further, as discussed below, the Commission should ensure the efficiency of all services in the 28 and 37/39 GHz bands by removing the outdated allowances for the use of omni-directional antennas.

2. The Commission Should Prohibit the Use of Omni-Directional Antennas in the 28 and 37/39 GHz Bands

In describing the significant capabilities of communications technologies in mmW spectrum, the *Order* repeatedly acknowledges the importance of highly directional antennas in overcoming the significant propagation losses in mmW spectrum and in ensuring efficient use of the 28 and 37/39 GHz bands. Without explanation, however, the *Order* borrows a significant exception from the Part 101 technical rules allowing the Wireless Telecommunications Bureau to permit licensees to use omni-directional antennas for fixed communications "with more than one point."[65] The vast majority of UMFUS systems will communicate with more than one point. Therefore, the exception for omni-directional antennas could eviscerate the rule.

This outcome was unreasonable and is unsupported by the record. No participant in this proceeding sought to use omni-directional antennas for point-to-multipoint services; the *NPRM*

[65] *See Order*, Appendix A (Final Rules), Section 30.406(a).

made no reference to this possibility; and such a practice would preclude highly efficient sharing within the coverage areas of such antennas. The indiscriminate transmissions from such hub stations, particularly if operated up to the authorized EIRP density limit, would blanket the area, overwhelming victim receivers that attempt to communicate with other systems. The interference caused by high-power, omni-directional antennas would not just preclude sharing with satellite earth station receivers, it would also preclude highly beneficial UMFUS services.[66]

The FCC should therefore remove the exception in Section 30.406(a) that permits the use of omni-directional antennas for fixed point-to-multipoint communications. By doing so, the Commission will reaffirm its direction that UMFUS licensees must employ directional antennas to ensure the efficient and productive use of mmW spectrum. Once modified, the rules would appropriately require the use of antennas that comply with the sidelobe levels of 30.406(b) for all transmitters operating in fixed point-to-point or fixed point-to-multipoint configurations.

III. THE ORDER ARBITRARILY DISREGARDS THE NEED FOR, AND SUITABILITY OF, FSS DOWNLINK SPECTRUM IN THE 42 GHZ BAND

The *Order* declined to adopt an FSS space-to-Earth allocation in the 42 GHz band, apparently concluding that future FSS networks are unlikely to need this downlink capacity.[67] In doing so, the Commission failed to reasonably explain its decision-making. To the extent that, as it appears, the premise of the Commission's decision was that no need exists, the Commission acted on a false premise that is not supported by the record.

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[66] The *Order* observes that terrestrial mmW systems "will enable various [Internet of Things] applications including wearables, fitness and healthcare devices, autonomous driving cars, and home and office automation." *Order*, ¶ 7. Such novel applications will not flourish if they may cease to function within range of a co-frequency omni-directional UMFUS transmitter.

[67] *Id.*, ¶ 368 (explaining that "[g]iven our decision today to grant FSS enhanced access to the 37.5-40 GHz band, and the fact that FSS has access to the 40.5-42 GHz band, we find there is less reason to further expand FSS operations in the 42 GHz band").

As the Commission is aware, all broadband services are asymmetrical, with consumers demanding far more downlink capacity as compared to uplink capability. The Commission has repeatedly questioned whether existing broadband satellite systems have sufficient downlink capacity, both with respect to satisfying speed requirements[68] and overall consumer demand.[69] To ensure that such perceived shortcomings are corrected in future satellite systems, the Commission must ensure that satellite systems licensed to operate in the V-band have sufficient capacity to provide highly competitive services to all consumers, with sufficient speed and capacity to offer a transparent alternative to terrestrial broadband offerings.

Boeing has designed its NGSO FSS network to satisfy anticipated consumer demand for broadband in rural and remote areas (employing speeds that exceed the Commission's broadband targets) and to serve on a technically transparent basis a significant market share of consumer demand in heavily populated areas. To achieve these important capabilities, however, Boeing's system will need access to a full five gigahertz of downlink spectrum, including full access to the 40.0-42.0 GHz band, shared access to the 37/39 GHz band, and access to the 42 GHz band.

In seeking access to five gigahertz of downlink spectrum, Boeing has emphasized that its system will be able to share spectrum on a co-frequency basis with other broadband satellite systems in the V-band, including other NGSO and geostationary systems. Further, just as Boeing's NGSO FSS system could share the 37/39 GHz band with terrestrial UMFUS licensees, Boeing's system could also share the 42 GHz band as long as reasonable regulatory measures are adopted defining the characteristics of both services. Therefore, the Commission should reconsider its decision to refrain from adopting an FSS allocation in the 42 GHz band.

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[68] *See 2016 Broadband Progress Report*, ¶¶ 3, 48.

[69] *See id.*, ¶ 47 n.162.

IV. THE ORDER ARBITRARILY AND UNNECESSARILY DISCOURAGES THE PLACEMENT OF SATELLITE EARTH STATIONS IN RURAL AREAS

The *Order* includes two general rules on the location of protected earth stations in the 28 and the 37/39 GHz bands that were developed with the stated intent of encouraging satellite system licensees to locate their protected earth stations "in places with comparatively low population densities."[70] The practical effect of these rules, however, will be the opposite.

First, the rules permit a maximum of only three earth station protection zones in each county or partial economic area ("PEA"). The impact will be to force satellite system operators to locate earth stations in more populated PEAs because there are not enough rural PEAs to accommodate all the earth stations needed by satellite system operators. Only some of the 416 PEAs in the United States are primarily rural. Even if satellite operators located three earth stations in each of the 416 PEAs (regardless of their population density), that would only allow for about 1,248 earth stations. This is far less than the several thousand earth stations that will be needed to support NGSO satellite systems in the V-band. Next generation NGSO satellite systems are being designed to employ narrow beams and very high frequency reuse to provide very high speed broadband services. Each of the satellites in these NGSO systems will require many dozens of gateways to support the traffic. Further, some recently proposed Ka-band NGSO systems plan to operate their gateway earth stations using V-band spectrum.

To accommodate Boeing's overall gateway earth station requirements, Boeing is planning to locate relatively large numbers of gateway earth stations in some of the more rural PEAs in the United States where they are unlikely to have any impact on UMFUS licensees. The Commission should encourage this by removing restrictions on the number of gateways that

[70] *Order*, ¶ 92.

can be accommodated in each PEA, allowing satellite system operators to locate as many gateways in rural PEAs as the operational characteristics of their satellite systems permit.

Second, the newly adopted rules require that protected earth stations be located so that they do not place more than 0.1 percent of the relevant population (county or PEA) in the earth station's exclusion zone.[71] Here again, this restriction was adopted to encourage satellite system operators to locate earth stations in rural and remote locations. Compliance with the 0.1 percent limit, however, will be easier to achieve in areas with moderate to higher population densities (where 0.1 percent of the population may be a reasonably high number).

In developing its 0.1 percent restriction, the Commission apparently assumed the use of exclusion zones with a radius of around 160 to 200 meters.[72] Since the adoption of the *Order*, however, there have been indications that such small exclusion zones may be impractical because of the near-field properties of large satellite earth stations[73] and therefore bigger exclusions zones (such as 2 to 5 kilometers) may be required.[74]

To assess the likely impact of the 0.1 percent restriction, Boeing performed several studies on locating satellite earth stations in the United States. The studies indicated that it may be possible to locate three geographically-separate earth stations in some PEAs without exceeding the 0.1 percent restriction, but in most of those PEAs, the average population density exceeds 100 people per square kilometer. As the average population density falls below 100 people per square kilometer, the ability to locate three geographically-separate earth stations

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[71] *See Id.*, ¶¶ 54 and 93.

[72] *See id.*, ¶¶ 55 and 110.

[73] *See* Comments of Nokia, GN Docket No. 14-177, at 17-19 (Sept. 30, 2016); Reply Comments of The Boeing Company, GN Docket No. 14-177, at 29-32 (Oct. 31, 2016).

[74] *See Joint Filers Letter*, Exhibit E at E-1; *see also* Samsung *Ex Parte* Letter (May 19, 2016).

becomes much harder. In fact, in the most rural PEAs, the population percentage affected by the exclusion zones for three earth stations occasionally reaches as high as one percent.

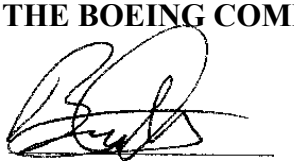
Of course, one percent of the population in a very rural PEA is a very small number of people. Likely for this reason, in each of the studies, Boeing was able to locate upwards of 2,800 earth stations in the United States without creating exclusion zones that affected more than 0.1 percent of the total U.S. population. To achieve this, however, Boeing needed to disregard both the 0.1 percent restriction in rural PEAs and the restriction on three earth stations in each rural PEA. Given these facts, Boeing urges the Commission to instead impose a substantively similar but more flexible restriction on the locations of protected satellite earth stations. For example, an appropriate restriction would be to allow the exclusion zones from all satellite earth stations operating in each spectrum band to not exceed 0.1 percent of the U.S. population.

V. CONCLUSION

The Commission should promote highly efficient and beneficial spectrum sharing in mmW spectrum, and seek to ensure that this spectrum is used to provide broadband services to all Americans, by adopting the changes in its rules identified in this petition.

Respectfully submitted,

THE BOEING COMPANY

By: 

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